CAR DAMAGE SEVERITY ESTIMATION FOR INSURANCE

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ABSTRACT

With the increasing demand for faster and more efficient insurance claim processing, AI-operated solutions are transforming how car damage severity is assessed. Traditional manual inspections—dependent on human evaluators—are time-consuming, costly, and prone to errors, often resulting in delays and dissatisfaction. This paper presents an AI-driven system designed to overcome these challenges by automating car damage evaluation. The system employs YOLOv8 for real-time object detection to identify damaged car parts, while MobileNetV2 is used for classifying the severity of the damage.For estimating the cost, the system uses a JSON-based cost evaluation module. Image preprocessing techniques such as data augmentation and perceptual hashing are applied to improve model generalization, ensure data integrity, and eliminate duplicate images, thereby optimizing computational efficiency. MongoDB is used for scalable data storage, and Pandas is leveraged to generate structured PDF reports containing detailed information about the damage, severity, and estimated repair costs. Unlike traditional methods, this AI-powered approach enables rapid, reliable, and automated damage assessments, streamlining the insurance claim process while improving accuracy, efficiency, and transparency.

Keywords: Car damage detection, YOLOv8, MobileNetV2, JSON-based cost estimation, AI in insurance, image preprocessing, perceptual hashing, automated claim processing

1. INTRODUCTION

To meet the growing need for faster and more efficient insurance claim processing, this project presents an AI-powered system that automates car damage severity estimation. Using YOLOv8 for damage detection and a lightweight MobileNetV2 model for classification, the system identifies issues like dents, bumper damage, mirror or hood damage, and windshield cracks. It replaces slow, error-prone manual inspections with real-time, accurate analysis that works efficiently even on low-end hardware. Once the severity is determined, repair costs are estimated based on standard industry rates, eliminating the need for manual cost evaluation and speeding up the claim process. MongoDB ensures efficient data storage and management, while the Phash algorithm detects and removes duplicate reports to maintain data

accuracy. The system also leverages Pandas, to provide structured PDF reports, which also contains relevant details about the damage, severity level, and estimated costs.Overall, this project provides a smart, reliable, and scalable solution which brings speed, accuracy, and transparency to car damage assessments and insurance claims.

2. PROBLEM STATEMENT

Manual car damage assessment methods are slow, costly, and often inaccurate due to reliance on human judgment. Current systems accept only image inputs, lack real-time processing, and have no mechanism to detect duplicate claims, increasing the risk of fraud. Additionally, the absence of AI-powered severity evaluation and automated cost estimation leads to delays and inconsistent results. There is also a lack of detailed, structured reports, which hampers transparency and efficient claim handling. An AI-driven solution using deep learning and image processing is needed to automate assessment, detect duplicates, and generate comprehensive reports for faster, more reliable insurance claim processing.

3. PROPOSED METHOD

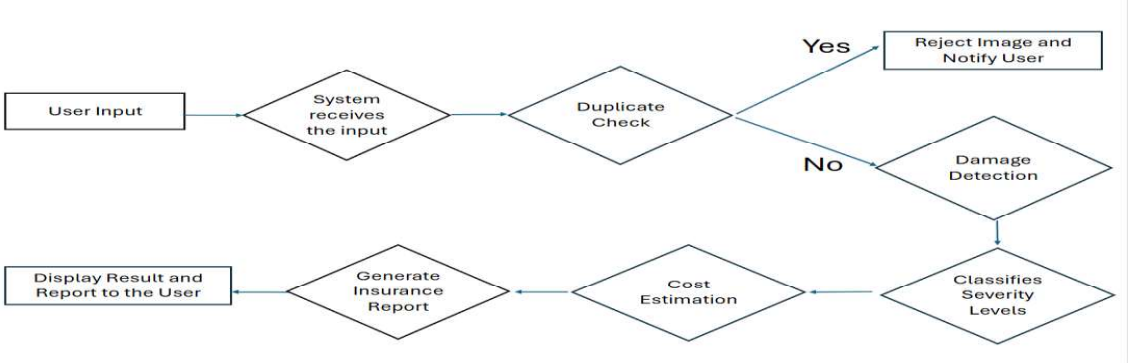

Figure 3.1: Workflow of the Car Damage Severity Estimation System

3.1 DUPLICATE DETECTION

The system employs Perceptual Hashing (pHash) to analyze duplicate images by their visual content, rather than using exact data to compare images, meaning that duplicate images can be recognized even through alterations of pixels.

$$DCT(u,v) = 1/4\, C(u)C(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} I(x,y) \cos\left(\frac{(2x+1)u\pi}{2N}\right) \cos\left(\frac{(2y+1)v\pi}{2N}\right) \quad (3.1.1)$$

The system will compare the binary hash with the ones that have been stored in the MongoDB and solve for the Hamming Distance,

$$H(A,B) = \sum_{i=1}^{n} (A_i \oplus B_i) \quad (3.1.2)$$

If the distance is less then the system will raise a duplicate image alert.

3.2 OBJECT DETECTION

Object detection plays a vital role in identifying damaged car areas before severity estimation, using the YOLOv8 model for its real-time accuracy and speed. The dataset is preprocessed by converting images to JPG format, resizing to 640×640 pixels, and labeling with .txt files in the format (class_id center_x center_y width

height), supported by a data.yaml file defining class names and image paths. YOLOv8 is trained using the Ultralytics library with transfer learning—starting with frozen backbone layers and gradually fine-tuning them. Training uses a batch size of 22, 50 epochs, a 0.001 learning rate, and the Adam optimizer. Data augmentation with Albumentations improves model robustness, and learning rate adjustments are handled using ReduceLROnPlateau.

3.3 SEVERITY CLASSIFICATION

Severity estimation is essential for evaluating vehicle damage by classifying its seriousness to support insurance claims and repair cost estimation. This is achieved using a deep learning model, "mobilenetv2_model.h5," trained on real-world car damage images to categorize damage into minor, moderate, severe, or uncertain. The model, loaded in a non-trainable state, processes images resized to (1, 224, 224, 3), extracting features like dent depth, crack patterns, and paint damage using optimized convolutional layers,data augmentation methods such as rotation, zooming, brightness adjustment, and flipping are applied. The MobileNetV2 architecture is modified through advanced preprocessing, real-world-oriented dataset structuring, and a two-stage fine-tuning approach. Initially, the final layers are trained for 10 epochs with the backbone frozen, followed by unfreezing the last 50 layers and fine-tuning with SGD for better generalization.

4. PERFORMANCE METRICS

The system's performance is assessed based on multiple overall accuracy metrics. The overall accuracy of the model is 97.6%, which indicates that the model is expected to produce reliable results when detecting and classifying damaged vehicles.

6. REFERENCES

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BIOGRAHIES

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